

successfully ligated the middle meningeal artery. Numerous other cases of this sort might be cited, but enough have been quoted to prove my proposition.

[To be continued.]

AN EXPERIMENTAL AND CLINICAL STUDY OF AIR-EMBOLISM.

[Continued.¹]

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VIII. IMMEDIATE CAUSE OF DEATH AFTER INTRA-VENOUS INSUFF- FLATION OF AIR.

VARIOUS theories have been advanced to explain the injurious effect of the presence of air in the circulation. Bichât (Physiological Researches on Life and Death, p. 186) attributed death resulting from intra-venous injection of air to cerebral anæmia produced by the presence of air in the cerebral vessels, asserting at the same time that a very small quantity would suffice to produce this effect. As the first argument in favor of this view, he claims that the heart continues to beat for some time after the cessation of animal life. Secondly, air injected through one of the carotids produces death in the same way as when introduced into the veins. Thirdly, the cases reported by Morgagni, where death was attributed to the presence of air which was found in the cerebral vessels at the post-mortem examination, and which was supposed to have developed there spontaneously. Fourthly, all examinations after death revealed the presence of frothy blood, mixed with air-bubbles, in both ventricles. Fifthly, air

¹ Continued from Vol. I., p. 549, June, 1885.

injected into one of the divisions of the portal vein produces no ill effects until it reaches the general circulation. Sixthly, the almost instantaneous death observed in some instances is due to the acceleration of the heart's action, and consequently the rapid conveyance of air into the cerebral vessels. Seventhly, the existence of convulsions, which he ascribes to the irritating quality of the air on the brain. He summarizes as follows: "We shall conclude that in the accidental mixture of air with the blood of the venous system, it is the brain which dies the first, and that the death of the heart is the consequence of the death of the brain."

Magendie, in commenting on Bichât's views concerning the manner of death from intra-venous injection of air, remarks: "This is not correct, and death takes place, on the contrary, by the cessation of the motions of the heart. The right ventricle is filled with air, and this air, dilated by heat, so distends it that it can no longer contract." Magendie also claims that small quantities of air in veins will not result in death, and that life is in jeopardy only when the air is injected suddenly and in considerable quantity. He relates the details of an experiment which he made on a horse, where he injected in rapid succession into the veins of the animal 40 syringes full of air, and three syringes full into the carotid artery. The capacity of the syringe was 17 centilitres. The animal died three minutes after the last injection. At the examination of the body, he found the air in the azygos vein and in the thoracic duct, which contained much lymph, as well as in the lymphatic vessels of the internal surface of the lungs. The heart was enormously distended with air, mixed with a small quantity of blood. Morgagni, Brunner, Sprægel, and Nysten referred the cause of death to the same source—over-distention and paralysis of the heart. When death is not produced by the mechanical effect of the air on the heart, then the consecutive symptoms were referred by Nysten to an obstruction of the lungs, produced by the accumulation of air in the ultimate divisions of the pulmonary artery. He observed that the embarrassment in respiration often appears as late as twelve hours after the introduction of the air, and becomes greater and greater; the bronchi are filled with a viscid fluid, and the ani-

mal usually dies on the third or fourth day. In such instances no air was found in the heart or the vessels; but the lungs, instead of being pink colored, were grayish, tinged with brown and loaded with frothy blood and mucus. The same views were entertained by Bœrhave, Kettler, and Beck. In such cases death results from asphyxia from the mechanical obstruction to the passage of the venous blood through the pulmonary circulation. Mery accepts the views of Mercier, published in 1839, who attributed death to this, that the blood, mixed with air, becomes frothy, enters the pulmonary capillaries, and obstructs them. Physicists are aware that a capillary tube, which readily admits the passage of air or water, offers a great resistance to a mixture of air and water; this mixture causes a series of bubbles separated by minute septa of liquid. Poiseuille has shown by a series of experiments that such, in fact, is the cause of death whenever air mixed with blood has obstructed the pulmonary capillaries. The right heart remains over-distended, and cannot be emptied.

Blundel (*Medico-Chir. Trans.*, Vol. IX., p. 65) studied the effects of the intra-venous injection of air in his experiments on transfusion of blood. He injected 5 drachms of atmospheric air into the femoral vein of a small dog in quantities of a drachm each at a time, without any serious effects. The symptoms observed were sighing respiration, irregular pulse, muscular tremors and vomiting, all of which, however, subsided after a brief space of time, and the animal recovered completely in three days. A second experiment was made on the same animal by blowing three drachms of pulmonary air into the femoral vein, without even producing much *temporary* inconvenience. He concluded that it seemed indisputable that small quantities of air may be introduced into the circulation without destroying life. Dr. Haighton made the same experiment with intra-venous injection of air, with like results. A series of experiments were made by Panum (*Experimentelle Beiträge zur Lehre von der Embolie*, Virchow's Archiv., Vol. V., p. 499). The subject of the first experiment was a small dog, in which five cubic centimetres of air were injected into the lower portion of the jugular vein. No symptoms followed immediately after the operation. Four days subsequently the

weight of the animal was reduced from 3540 to 3030 grammes. The tissues around the point of puncture were inflamed. On the fifth day the animal was killed. The skin of the animal was dotted with spots of ecchymosis, resembling the extravasations as they occur in the disease known as *morbus maculosus Werlhofii*. In the vicinity of the wound the tissues were emphysematous, emitting an offensive odor. Among other post-mortem appearances, the lungs presented several gray superficial stripes and spots, one-half line in diameter. In the middle of several of these patches were found empty spaces, which Panum regarded as encysted air-bubbles. In addition, small isolated nodules were also found, which contained in their interior small bubbles of air. These nodules contained also numerous nuclei and fat-globules. In the second experiment 10 cubic centimetres of air were injected into the lower portion of the jugular vein of a small one-year-old dog. During the first three days nothing was observed with the exception of rapid emaciation. On the fourth day the animal began to loose the hair, not only in the vicinity of the wound as in the first case, but over the entire surface of the body. Later, inflammation and ulceration attacked the point of operation. On the eleventh day the animal was killed. The lungs again presented sub-pleural nodules, from the size of a pin's head to that of a grain of sand, in which could be found large cells filled with fat molecules, granular cells, and fat-globules in large number. Air could not be found in any of them, and their relation to the capillaries of the pulmonary artery could not be determined. In the third experiment, 30 cubic centimetres of air were injected into the jugular vein, without producing any alarming symptoms, except rapid and deep respiration. The next day no change was observed, but on the following day the animal was found dead. A careful examination revealed punctiform extravasations in different portions of the brain, stomach and liver. The wound showed a healthy appearance. The lungs contained many very small yellowish white nodules and points of extravasation, one to two lines in diameter. The hemorrhagic infarcts contained each a minute cavity filled with air. The nodules also contained air. From these experiments it appears that

the air emboli which passed through the pulmonary capillaries produced local disturbances in the minute vessels in the skin and gastro-intestinal canal, while the air emboli in the ultimate branches of the pulmonary artery gave rise to circumscribed foci of inflammation. Picard (*Sur les injections de l'air dans la veine porte*, *Gaz. Méd. de Paris*, No. 6, 1873) found after insufflation of air into the portal vein intense hyperæmia in the distal portion and radicles of the vessel, the same as after ligation. At the commencement of the insufflation, the blood pressure in the femoral artery and one of the rectal veins was about the same; but after a while the pressure in both was simultaneously diminished, but the positive pressure lasted longer in the vein than in the artery. The action of the heart was increased, the respirations became slower and the temperature in the rectum was gradually reduced. As an interesting physiological fact it is mentioned that after insufflation of air into the portal vein no sugar could be found in the liver, and the fibrin in the portal blood was diminished. The experiments of Magendie, Bouillaud, and later, those of Couty (*Etude expérimentale sur l'entrée de l'air dans les veines*, Paris, 1875) proved conclusively that in cases of entrance of air into a peripheral vein the air collects almost exclusively in the right side of the heart; only a minute quantity entering the left side through the pulmonary capillaries. Referring to this question, Flint says: "The production of death from air in the veins is purely mechanical. The air finding its way to the right ventricle is mixed with the blood in the form of minute bubbles, and passed into the pulmonary artery. Once in this vessel, it is impossible to pass through the capillaries of the lungs, and death by suffocation is the inevitable result if the quantity of air be large. It is because no blood can pass through the lungs that the left cavities of the heart are usually found empty." (*Physiology of Man, Blood, Circulation, Respiration* (1866), p. 323.) If the quantity of air introduced is small, or the entrance repeated in small quantities, the air collects in the capillaries of the pulmonary artery, as air emboli, obstructing the circulation in the impacted vessels, but a sufficient number of vessels remain pervious to maintain the circulation, and life is prolonged until

the equilibrium of the circulation is restored by the absorption of the adventitious air. No traces of air are found in the arteries, only a small quantity passing into the venæ cavæ through the tricuspid valve, which has been rendered insufficient by the presence of air. When a considerable amount of air has entered the right ventricle of the heart, mixed with the blood, the air is separated from it, and its specific gravity being less, it rises to the highest point of the chamber in contact with the anterior walls; besides it expands, and by its over-distention it impairs the muscular contractility, which even in a normal condition is insufficient to empty the cavity completely. The impediment to the circulation being the presence of the large air embolus in the right ventricle, which, on account of the higher temperature, increases in volume, sudden death will take place in the diastole by an arrest of the heart's action from paralysis by over-distention. If the animal escapes instantaneous death from this cause, the heart is inadequate to force the blood from the right ventricle through the pulmonary circulation, as its efforts are expended in compressing the air; only a minute quantity of blood being forced into the lungs. In proportion as the amount of air and blood in the right ventricle increases, the right side of the heart is expanded, and the volume of blood in the lungs and the left heart is diminished. At last the distended walls of the heart prevent perfect closure of the tricuspid valve, giving rise to venous pulsation, a constant symptom in all cases of air-embolism, which prove rapidly fatal. On the advent of this complication the intra-arterial pressure in the pulmonary and peripheral arteries diminishes, which further enfeebles the pulmonary circulation; at the same time it produces acute anæmia of the brain, and death results from anæmia of the brain or asphyxia. Such is the mechanism of death in cases of entrance of air into the venous circulation, and, at the same time, it offers an explanation why in these cases the air is found mostly in the right side of the heart and the large venous trunks. These facts also corroborate the observations of experimenters that certain animals succumb more readily to the presence of air in veins than others. The tolerance of intra-venous air is most marked in animals with

well developed respiratory organs and a proportionately powerful right ventricle. In horses, for example, the volume of the right cavity is smaller and the muscular structure more powerful—circumstances which explain the fact that entrance of air into the veins of these animals does not easily kill them. The circulatory apparatus of the dog offers the least resistance to intra-venous air. Rey blew air into the jugular veins of horses after venesection without producing death. Small amounts of air produced no result whatever, and a volume of air equivalent to two expirations proved fatal only in debilitated animals. Some animals remained well after leaving a canula in the jugular vein for several hours. Death was sure to follow if, after insufflation of air, the vein was ligated. Animals who have previously lost large quantities of blood readily succumb to intra-venous admission of air.

Laborde and Muron, who studied the effects of intra-venous and intra-arterial insufflation of air, placed great stress on the manner in which the injections are made in determining the gravity of the symptoms. They observed that in case the insufflations into veins are made slowly, and repeated at intervals, large quantities were tolerated without exciting serious symptoms. If, on the other hand, they were made suddenly and with force, and the quantity of air was considerable, death resulted almost instantaneously from arrest of the heart's action in the diastole, an occurrence which was attributed by these authors to over-distention of the right side of the heart.

In repetition, it may be stated that the immediate cause of death after intra-venous injection of air has been referred by different experimenters to:—

1. Mechanical over-distention of the heart and paralysis of this organ during the diastole.
2. Acute cerebral ischæmia.
3. Asphyxia from obstruction to the pulmonary circulation subsequent upon embolism of the pulmonary artery.

IX. INTRA-ARTERIAL INSUFFLATION OF AIR.

As the accidental admission of air never takes place in wounds of the arteries on account of the high degree of intra-

vascular pressure, and the absence of any aspiratory force, it is not surprising that the effect of the artificial introduction of air into these vessels has been made less frequently an object of experimental research than intra-venous insufflation of air. The subject is devoid of any practical value, and the interest attached to it is purely of a scientific nature. As we have already seen, Bichat entertained the idea that atmospheric air acts as a direct irritant to the substance of the brain when brought into contact with that organ through the medium of the cerebral vessels, and death from insufflation of air whether into veins or arteries, was invariably attributed by him to cerebral anæmia. Panum (*Op. Cit.*), in his researches on embolism, made arterial insufflation of air also a subject of experimentation. A rapidly fatal termination followed the injection of 40 centimetres of air into the lower portion of the carotid artery of a medium-sized dog. The infundation was superseded immediately by severe general convulsions, alternated by violent attacks of rage. The animal foamed at the mouth, and had involuntary discharges from the bladder and bowels, the eyes became prominent, and the pupils, at first dilated, contracted and remained so, permanently. The animal soon became quiet and motionless. Respiration and heart's action slow. The right anterior and both posterior extremities were extended, and rigid, while the left front leg remained relaxed. Conjunctiva insensible, while touching the cornea, produced contractions of the eyelids. For two hours the animal remained in a condition resembling anæsthesia, without changing its position, with slow pulse and respiration, when life ceased without a tremor or convulsion. The post-mortem examination showed numerous punctiform ecchymoses in the gastro-intestinal mucous membrane, the liver, diaphragm, and abdominal muscles. The superficial vessels of the brain, more particularly the veins, were extremely hyperæmic; the jugular veins were distended to their utmost with blood. The small arteries contained many air-bubbles, so that the smallest vessels presented varicose dilatations which resembled a string of pearls. The large vessels at the base of the brain also contained air, and numerous red spots were disseminated throughout the white substance of the brain.

Laborde and Muron (Virchow u. Hirsch's *Jahresbericht*, 1873, Vol. I., p. 268), witnessed after the introduction of 20–60 c. cm. of air into the carotid artery of dogs, when injected in a peripheral direction, that death was produced rapidly and was always preceded by tetanic convulsions and labored respiration; while, if the quantity of air was thrown in, in divided doses, the animal often survived the experiment for 24 hours. In the latter class of cases the operation was followed by tetanus, vomiting, paralysis, and coma. The autopsy revealed softening of the brain, and capillary hemorrhages, especially in the middle portion of the brain, the medulla oblongata, and in the posterior lobes of the cerebrum. The intra-arterial insufflations of air in all these experiments were immediately followed by grave cerebral symptoms, which can only be interpreted by the constant post-mortem appearances,—air embolism of the cerebral vessels, and extreme ischæmia of the brain. The presence of air in the arteries, or the left side of the heart, is followed by an entirely different series of phenomena than in the veins or the right side of the heart. The acute ischæmia of the brain thus induced, is invariably manifested by tetanic rigidity of the voluntary muscles, and almost complete suspension of the respiratory movements of the chest. The contractions of the left ventricle are so powerful as to overcome these additional impediments, and to completely evacuate the chamber. The air is expelled as soon as it enters, and is distributed throughout the whole arterial system. It must be readily conceived that the air when it has reached the aorta will rise into the carotid arteries, and thence into the cerebral vessels, distending them to their utmost capacity. In such instances death results from sudden cerebral anæmia before the air can gain entrance into the venous system through the capillaries. That the presence of air is detrimental to the nervous system has been established by experiments on animals. Bohnius attributed to the air, when introduced into the vascular system, poisonous properties, and this opinion is entertained by Neudörfer, even at the present time. Copeland believed that the oxygen of the adventitious air combines with the carbonic oxide in the venous blood producing carbonic acid. These and similar theories do not explain

the phenomena observed after insufflation of air. The symptoms during life, and post-mortem appearances, point directly towards physical obstruction in the blood vessels by air emboli which suspends the function of one of the vital organs and consequently must be regarded as the immediate or direct cause of death. Insufflation of air into the carotid artery towards the brain is almost immediately fatal. If a moderate quantity of air is forced through the arterial system into any other organ except the brain, except by forming a temporary obstruction in the circulation, it does no particular harm, and is in a short time removed by absorption. This fact may have induced Flint to make the following remarks concerning this subject (*Op. cit.*, p. 324): "Air injected into the arteries produces no such serious effects as air in the veins. It is arrested in the capillaries of certain parts, and in the course of time is absorbed without having produced any injury."

The danger arising from the introduction of air into the arteries or left side of the heart, arises from obstruction to the circulation through the cerebral vessels by air-emboli and the cessation of the functions of the brain consequent upon an almost complete ischæmia of this organ. The mechanical distention of the left side of the heart, by the accumulated air, is overbalanced by the powerful contractions of the left ventricle, which are sufficient to empty the chamber almost completely, and to force the air into the ultimate distributions of the arteries, causing acute anæmia in distant organs, but more particularly in the brain. In these instances the air is forced directly into the cerebral vessels either by the injecting force or the powerful contractions of the left ventricle, and if death takes place it follows as the direct result of acute cerebral ischæmia.

X. CLINICAL STUDY OF AIR-EMBOLISM.

All physiologists agree that regular and deep inspirations produce a powerful aspiration in the large veins near the base of the heart, more particularly in the jugular and subclavian veins. This fact is so well known that the base of the neck and the clavicular regions are frequently referred to as the "danger-zone." During the inspiratory act the chest expands,

and the flow of venous blood is accelerated towards the cardiac or proximal side. A diversity of opinion still exists among authors in regard to the distance to which this force directly affects the venous circulation. Experiment and clinical observation have shown that the danger of entrance of air into wounded veins is increased as the wound approaches the heart. Berard studied the anatomical conditions of the vessels where entrance of air has most frequently taken place, and he came to the conclusion that this accident can only happen in the event when a wounded vessel is empty, and its walls are prevented from collapsing, and the wound remains patulous. He found these conditions normally present in the sinuses of the dura mater, the hepatic veins, the superior vena cava, the internal jugular, the subclavian, and the axillary veins, because the walls of all these vessels are firmly fixed to the adjacent tissues, which prevents their collapse on being wounded. It has further been shown that the admission of air is favored by pathological conditions which affect the veins in a similar manner, as the existence of induration of their walls, the result of chronic inflammation, or infiltration by neoplasms. Experience has corroborated these views, inasmuch as it has been shown that this accident has occurred most frequently in operations in the vicinity of veins which, from their anatomical location are prevented from collapsing by firm and unyielding layers of fascia and vessels which are, or have become, adherent to unyielding tissues. Again, it is always very justly feared in removing tumors which have become adherent to large veins, as the morbid process frequently has impaired the normal resiliency of the vessel so as to keep its lumen patent in the event it is wounded during the dissection.

In 33 cases of intra-venous aspiration of air collected by Couty (*Op. Cit.*) air entered the external jugular nine times, the axillary eight times, the internal jugular five times, the subscapularis three times, the facial twice, the anterior jugular twice, the occipital twice, and twice one of the anterior thoracic veins in close proximity to the clavicle. In 1864 Green collected 67 cases where air had entered a vein during an operation. The greater number of cases occurred during extirpation of tumors in the region of the neck, chest and

axilla. Twice the accident took place in disarticulating the humerus at the shoulder joint (Cooper, Delpech); once, on extirpating the scapula and clavicle (Mussey); twice, on tying the subclavian artery (Clemot, Rigaud); three times on bleeding from the external jugular vein, three times from bleeding from median vein, and once on passing a seton-needle through the tissues in the region of the neck. Among the wounded veins, the external jugular is mentioned thirteen times, the internal jugular ten times, the subclavian and axillary, each, once. In the remaining cases the vein is not specified or the injury involved a branch in close proximity to the specified vessels. (*Amer. Jour. Med. Sciences* (1864), p. 38.) All causes which interfere with the free return of venous blood prevent the admission of air, while, on the other hand, all influences which promote the venous circulation, such as an unimpaired *vis a tergo*, regular deep inspiration, and the force of gravitation predispose to this accident. Soon after Beauchène made known his case, the Royal Academy of Medicine of Paris appointed a commission to investigate the subject. In the report it is stated, that the results of the experiments, which were made, principally on dogs, had proven that the conditions necessary to determine the entrance of air consisted in making the wound in the vein anywhere within the area of the venous pulse, or, at any rate, only a short distance from it. If the wound was located at a greater distance and beyond the influence of the venous pulsations, no air would enter, although the wound was kept open. The experiments were also to determine the extent of the venous pulse, and the conclusions arrived at were that the brachial and axillary veins were beyond the venous wave, while the subclavian and lower third of the jugular veins were the seat of pulsations, consequently wounds of the veins in these localities were liable to admit air. The sound produced by the entrance of air is described as resembling the lapping of a cat or dog, and that it always occurred during, and synchronous with, inspiration; but sometimes, when it was heard more frequently, it accompanied the diastole of the right ventricle. After the air had entered the vein, the sound, which could be heard on auscultation over the heart, was described as a "bruit de soufflet," synchronous with

the action of the heart. In regard to the effect of the aspirated air, it was decided that, in order to produce a fatal result, it was not only necessary that the amount of air introduced should be considerable, but that it must be thrown into the vein with some degree of force.

Hertwig called special attention to the fact, that aspiration of air is not as frequent an accident as is generally supposed, and that for its occurrence it is necessary that the peripheral flow of blood to the wound must be obstructed; that the edges of the vein wound must be drawn apart; and finally, that even the introduction of a canula into the vein is necessary to admit a sufficient amount of air to produce serious results.

The first case of admission of air into a vein that was recognized and verified by a post-mortem examination, occurred in the practice of Beauchêne, and is described by F. Magendie (*Physiological Researches on Life and Death*, by X. Bichât, with notes by F. Magendie; Translated Boston, 1827, p. 188). As the case is of great historical and scientific interest, I will relate it as described by Magendie: "A locksmith, 23 years of age, had for five years a large tumor on the right shoulder and clavicle. His acute sufferings induced him to enter the hospital to have it removed. It was necessary, in the operation, to remove the middle portion of the clavicle. Thus far the success was complete; but little blood was lost, the pulse was good, and the breathing easy, when the patient suddenly cried out: 'My blood is leaving my body! I am dead!' At the same moment he became stiff, lost his consciousness, and was covered with a cold sweat. A singular and rather loud noise was heard in the interior of his chest. The surgeon thought he had opened the pleura by removing a portion of the clavicle, and thus given access to the air, and to the blood to the right side of the thorax. The fingers of an assistant were immediately thrust into the bottom of the wound, with a view of stopping the supposed opening in the pleura, and the surgeon endeavored to introduce into the thorax the extremity of a sound of gum-elastic. When he thought that he had succeeded, he drew with his mouth the air which he supposed to be effused in the plura. He wished then to proceed to the dressing, and, in order to do this, he substituted

for the fingers of the pupil, which were at the bottom of the wound, a sponge covered with wax; but the moment the sponge took the place of the fingers, the same noise that was at first heard, and which had ceased in an instant, was renewed with more force than before. The syncope and cold sweat still continued. Water thrown into the face made him give some signs of life, but he died a quarter of an hour after the appearance of the accident I have first described, and forty-five minutes after the commencement of the operation. The body was examined the next morning. They expected to find the right pleura open, much blood and air effused into its cavity, and the lungs on that side collapsed. Nothing of the kind was found. The pleura was whole and there was no effusion in it. The lungs were as usual, but an opening of half an inch in extent was discovered in the external jugular vein, at the place where this vein opens into the subclavian. The cavities of the heart were large, but contained no blood. Bubbles of air were observed in the vessels of the brain; the other vessels were not examined."

In order to study some of the conditions under which air has been aspirated into veins, and for the purpose of ascertaining the effects of such accidents in man, I will introduce a number of well authenticated cases which will represent a great diversity in the point of entrance, and will also aid in the establishment of the fact that this accident can occur outside of the regions of venous pulse, and always occurs during inspiration, and is never produced by the aspiratory function of the heart.

External Jugular. Barlow's case. (*Med. Chir. Trans.*, Vol. XVI., p. 29.) The patient was a female, suffering from a tumor seated on the side of the neck, which had been increasing in size for several years; its base was extensive, and occupied the whole of the lateral and posterior parts, extending from the ear to near the sternum, and sidewise from the thyroid gland to the sternomastoid muscle under which a part of the tumor was situated. The patient was seated in a reclining chair, supported by assistants. Two superficial elliptical incisions, ten inches in length, were made downwards from a little below the ear, "when on proceeding to dissect the skin aside to get at the

basis of the tumor, a sudden and unexpected hissing and gurgling noise rushed obviously from a large, divided, empty vein, and the patient expired instantly, without either sigh, groan, or struggle, and every effort to restore animation became fruitless." The divided vein appeared larger than the normal external jugular, but the reporter believes that it was this vessel or an anomalous vessel greatly enlarged. As the incisions must have traversed the external jugular, according to his own description, it was undoubtedly this vessel which was injured. It is distinctly stated that the vessel was flabby and empty, and that the instant the atmospheric air gained access and filled the vacuum, the hissing noise ceased. The patient expired, and the mouth of the vessel collapsed.

Remarks. In this case the admission of air was favored by the dilatation of the vein, and the semi-erect position of the patient. The latter factor produced the emptiness of the vein. The instantaneous death without any symptoms preceding it can only be explained by the fact that the air entered with force, and in large quantity the right ventricle and arrested the heart's action by over-distention.

Internal Jugular. Ulrich's case. (*Rust's Chirurgie.* Berlin, 1836, Vol. XVII., p. 565.) The operation was performed for the removal of a tumor involving the left side of the neck. It was found that the tumor was attached to the deep muscles of the neck, and in severing its connection the internal jugular vein was opened. No hemorrhage followed, the vessel remained open like an artery, and air entered immediately. The patient fainted, twitching of the muscles of the face, opisthotonos, a few slow respirations followed, and the patient was dead. The vein was found obliterated above the incision, and thickened and more resistant than normal where the wound was inflicted. The reporter attributed the ingress of the air to aspiration of the heart, and death to paralysis of this organ.

Remarks. The pathological changes in the vein above the wound interrupting entirely the column of blood from above as well as the thickening of the incised vein-walls were potent factors which determined the entrance of air. As this operation was performed before anæsthetics were used, we may be

almost certain that the patient was in a sitting or half reclining position during the operation, thus favoring greatly venous return and ingress of air. The entrance of air in this instance is brought, in connection with the suction power of the heart, by the author, in accordance with the then prevalent doctrine of the French Commission.

Internal Jugular. Dupuytren's case. (*Med. Chir. Trans.*, Vol. XVI., p. 301.) The operation consisted in the removal of a tumor of a fibro-cellular character of considerable size from the neck of a female 22 years of age. No serious obstacles presented themselves until the last deep attachment was severed with the knife, when suddenly a prolonged hissing noise (*soufflement prolongé*) was heard, resembling the sound produced by the entrance of air into a vessel from which it had been exhausted. The patient immediately proclaimed: "I am dying," and instantaneously dropped down on the floor, a lifeless corpse. As no other cause was found which could, in any way, account for the sudden death, the fatal issue was attributed to the entrance of air into the internal jugular vein. The following account of the post-mortem appearances fully warrant this supposition: The right auricle was distended with air like a bladder, which rushed out when cut open, without any admixture of blood. Fluid blood was found in the different vessels. Great quantities of air were found in all the vessels. There was no other unnatural appearance in any other part of the body.

Remarks. The editor of the *Medical and Chirurgical Review* explained the entrance of air in this case as follows: "It proves that the heart acts as a sucking as well as a forcing pump, otherwise air could never have passed from a cut vein in the neck down into the right chambers of the heart. It is highly probable that, in consequence of the morbid state of the parts, the mouth of the cut vein had remained patulous, and thus readily admitted the air." As no mention is made of the occurrence of hemorrhage, the vein was probably empty, a condition which might have been owing to the position of the patient during the operation, or the pressure of the tumor. It is also reasonable to assume that, on account of the intimate connection of the tumor with the vessel, the former so altered

the structure of the latter, as to prevent closure of the wound, all of these causes combined resulting in aspiration of air during inspiration.

Facial Vein. Mott's case. (*Ibidem*, p. 32.) The operation consisted in extirpation of the parotid gland, the seat of a scirrhus tumor. The facial vein was opened, where it passes over the base of the lower jaw, in dissecting the integuments from the tumor in the early stage of the operation before a single artery was tied. At the instant this vessel was opened, the attention of all present was arrested by the gurgling noise of air passing into some small opening. The breathing of the patient at once became difficult and laborious, the heart's action violent and irregular, his features were distorted, and convulsions of the whole body soon followed to so great an extent as to make it impossible to keep him on the table. He lay upon the floor in this condition for nearly half an hour, as all supposed in *articulo mortis*. The convulsions ceased gradually, his mouth was distorted, and complete hemiplegia was found to have taken place. After an hour had passed he could speak, but the use of his arm and leg was only recovered completely after the lapse of a day.

Remarks. Although not stated, it was undoubtedly true, that, in this instance, the facial vein was enlarged, and its walls had lost their normal resiliency, thus favoring the ingress of air. This case is also of interest, as from the predominance of the cerebral symptoms, it is apparent that some of the air must have passed through the pulmonary circulation and have gained access into the cerebral vessels from the left ventricle, giving rise to symptoms of cerebral embolism which disappeared as the air was absorbed.

Axillary Vein. Bransby Cooper's case. (*Med. Chir. Trans.*, Vol. XXVII., p. 41.) The patient was a female, 19 years of age, who was the subject of a malignant tumor of the right humerus, which required amputation at the shoulder joint. The operation was done by making a double flap, the subclavian artery in the meantime being compressed against the first rib. There was no loss of blood. The subclavian artery was secured, compression being kept up, as there were small vessels which required ligation. As

the operator was removing an enlarged gland from the axilla he heard distinctly a peculiar gurgling noise, like air escaping with fluid from a narrow-necked bottle. At the same moment the patient fell into a state of collapse which threatened immediate death. The face was deathly pale, the pupils fixed and insensible to light, the pulse small and fluttering, at intervals irregular, respiration hurried and feeble, and at irregular intervals, attended with a sigh. The patient was placed in the recumbent position, the flaps closed, and stimulants applied; but an hour elapsed before she had sufficiently recovered to be removed from the operating table. Subsequently, when placed in bed, she maintained a constant motion of alternate flexion and extension of the right leg, which continued for several days, at the same time she complained of pain, extending up the right side of the neck and head. The next day the pulse varied from 140 to 150 per minute, and remained the same for two days. She gradually rallied and recovered completely.

Remarks. In this case the axillary vein was divided at a point where its walls are firmly fixed and its lumen kept patent by dense connective tissue, which surrounds the vessel, a condition which predisposes to aspiration of air. Pulmonary air emboli obstructed the passage of blood through the lungs, a circumstance which would serve to explain the rapid respiration and the accelerated action of the heart, until the obstructing cause was removed.

Axillary Vein. Courvoisier's case. (*Correspondenz-blatt fuer Schweizer-Aerzte*, 1880, p. 205.) The operation was performed for the removal of a recurring cancer of the breast, and included the extirpation of infiltrated and ulcerated axillary glands. As the dissection reached the upper margin of the mass of axillary glands a lapping (schluerfend) sound was suddenly heard; at the same time the patient, a robust woman, 58 years of age, sank into a condition of collapse. The central portion of the vein was at once closed by digital compression, and artificial respiration with the administration of stimulants were successful in restoring her after the lapse of half an hour. Both ends of the vein were ligated, and the central ligature included the forceps which was allowed to remain. The patient recovered.

Remarks. In this instance the entrance of air was again determined by the anatomical location of the vein-wound to which may have been added cancerous infiltration of the paravascular tissues which rendered the vein walls still more unyielding. The amount of air admitted must have been small, to judge from the evanescent nature of the symptoms which followed.

Anterior Thoracic Vein. Amussat's case. (*Gazette des Hôpitaux*, July 6, 1837.) The patient was a woman, 47 years of age, suffering from a scirrhus affection of the right mammary gland and the subjacent and surrounding tissues. The breast and adjacent tissues had been removed, and the operator was dissecting towards the opposite side, when suddenly, on making an incision into some suspicious granulations on the inner side of, and below, the left clavicle, he and three other surgeons who were assisting him, heard a sudden, distinct, interrupted sound, as of air passing into a cavity through a narrow opening. The patient exclaimed: "I am dying," and appeared to be suffocating. A repetition of the same sound convinced the operator that air had entered through a wounded vein, and he placed his finger on the spot from which the sound proceeded. The patient's condition became critical; a cold sweat covered her face, her eyes were turned upwards, and all around her thought her dying. The orifice of the wounded vein could be distinctly seen. The chest was compressed with a view to force out the air from the vein, the wounded spot being compressed during the expansion of the chest. The patient soon began to show signs of improvement, when the operation was completed and the vein with a portion of the tissue was tied. The patient recovered completely.

Remarks. Although the particular vein wounded in this instance is not specified, it was undoubtedly a branch of the subclavian vein, the wound being in close proximity to the latter vessel. This case furnishes a good illustration of the fact that veins of comparatively small calibre, when wounded near their proximal termination into a large vessel may serve as points of entrance of air under the same circumstances as when the principal trunk is injured.

Superficial Cervical Vein. Trélat's case. (*British Med.*

Journ., March 16, 1872.) Mr. Trélat related at a meeting of the Société de Chirurgie of Paris, an important case in which sudden death occurred in a patient from whom he was proceeding to remove a submaxillary tumor. The patient turned ghastly pale, and the heart's action ceased suddenly. Artificial respiration and electrization of the phrenic nerve induced some respirations and a slight return of color after fifteen minutes, but ineffectually. At the post-mortem examination a small vein opening into the external jugular was found to have been partially divided; in the jugular was a long clot interspersed with air-bubbles, and other bubbles of air were found in one of the mediastinal veins, and the posterior cardiac vein, and a very notable quantity of air in the right chambers of the heart.

Remarks. Several members of the society argued that death in this instance was due to the anæsthetic and not to the entrance of air into the vein. Roux and Giraldès claimed that in several cases of death from chloroform they had found gases in the heart, in the vena cava, and even in the veins of the pelvis, but M. Depaul, in reply, properly and forcibly pointed out that the air in this case occupied only the veins going to the heart and the wounded vein.

Femoral Vein. The only well authenticated case of aspiration of air into the femoral vein that I have been able to find is recorded in the "Medical and Surgical History of the British Army in Turkey and the Crimea," Vol. II., p. 277, and refers to the sudden death from this cause of a soldier who had suffered amputation of the thigh. Three and one-half days after the operation he died suddenly without any obvious cause. At the necropsy, twelve hours after death, it was ascertained that the right cavities of the heart were distended with a mixture of blood and air, and the same condition was found in the two iliac veins and the inferior vena cava.

Remarks. As the time which had intervened between the operation and the fatal accident was more than three days, it is necessary to assume that the venous thrombus had been removed by suppuration, thus opening the vein for the admission of air, or that the supposed air found in the heart and vessels was not air, but gas which had developed in the wounded

parts, and had gained entrance into the venous circulation. This latter supposition is strengthened by the statement that the surfaces of the flaps were separated by gaseous products, and that the femoral vein was not closed, but lay open on the surface of the stump.

Internal Saphenous Vein. Warren's case (*Gazette Médicale*, No. 52.) The operation was done for the removal of a tumor from the inner surface of the thigh. In the dissection the internal saphenous vein was wounded; the event was promptly announced by an audible and distinct sucking sound produced by the entering air. No alarming symptoms followed, as the further ingress of air was promptly prevented by closure of the vein.

Uterine Veins. That the entrance of air into the uterine veins might be a cause of danger after parturition, was suggested by Legallois in 1829. Dr. John Rose Cormack read a paper on this subject before the Westminster Medical Society in 1850, when he gave the details of three cases that had occurred in his neighborhood. Many authorities doubt the possibility of admission of air into the uterine veins after labor. Julius M. Klob (*The Pathological Anatomy of the Female Sexual Organs* (1868), American Translation) alludes to this subject as follows: "I have not seen a case which convinced me that air had passed into the open veins of a recently delivered uterus, and I cannot conceive the mechanical possibility of such an occurrence. Bessems, Lionet, Lèver, Wint-rich, Berry and Simpson assert that they have met with such instances, and a sufficient number of well authenticated cases have been placed on record which leave no further doubt as to the possibility of sudden death in puerperal women from entrance of air into the uterine sinuses. In a recent number of the *Wiener Medicinische Zeitschrift*, Braun gives three fatal cases from the introduction of air into the uterine veins; in two of the three the uterine douche was used, in one to produce abortion, in the other after delivery of twins, and the patients died in a short time, one indeed, within twenty minutes. Post-mortem examination showed air in the uterine veins, in the ascending vena cava, and in the veins of the heart. The third case was that of a woman who had been

delivered lying upon her left side, and was then turned upon her back; massage was made over the uterus, she gasped and died in a few minutes. Braun suggests that in the change of position a volume of air entered the uterus, and the manipulation, instead of driving it out, forced it into the uterine veins. Bischoff refers to two cases that came under his observation (*Correspbl. f. Schweizerärzte* (1880), p. 206). Dr. Draper (*Boston Med. and Surg. Journal*, January, 1883) has reported two cases where instant death occurred from efforts to cause criminal abortion. The post-mortem examination proved in each case the presence of air in the veins.

Mr. George May (*British Med. Journal*, June 6, 1857) reports three cases which occurred in his vicinity. The patients died respectively, six hours, and eight days after delivery, and in all of them post-mortem examinations showed the presence of air in large quantities in the inferior vena cava and the right side of the heart. An interesting account of this accident is given by Dr. Geo. Cordwent, and relates to a case that came under his observation (*St. George's Hosp. Reports*, Vol. VI.). His patient was 26 years of age. During the delivery, at full term, her expulsive pains became urgent, and, at her request, she was permitted, in the presence of her medical attendant, to remain standing; after a few severe pains the child was expelled, and, after falling on the floor, dragged with it the whole placenta. Almost immediately afterward a kind of gurgling sound was heard by the attendants, but, whether it arose from rumbling in the bowels they could not say. The patient remained about one minute standing, as before, and holding on to the bed-post; she then cried out: "I can't see! I feel faint! Lay me on the bed!" and expired almost instantly. At the necropsy, 24 hours after death, it was shown that the uterus externally presented the normal appearances of a recently delivered organ, except that a portion of the wall of its fundus to about the extent of a five shilling piece was slightly more puffy than the other portions, and, on cutting into it, air-bubbles escaped. There had been no laceration of the placental surface; the uterine cavity contained only one small clot; its lining membrane was healthy. The coronary vein of the stomach was distended; the right side of the heart was

slightly gorged, and when the auricle was punctured air-bubbles escaped with the blood which it contained.

Davidson (*The Lancet* (1883), Vol. I., p. 999) reports the case of a Hindoo woman who had been admitted into the Kaira Gaol Hospital, and safely delivered of a female child. The labor was in every respect normal. The placenta came away at the usual time, and there was no post-partum hemorrhage. About three-quarters of an hour afterward the woman died without any apparent cause. There had been no hemorrhage or convulsions. The patient had been taking some nourishment, when she suddenly fell back and expired. At the post-mortem examination, two hours after death, the uterus was found empty, with large and somewhat distended veins; the right side of the heart contained a quantity of air, mixed and churned up with blood, which escaped in bubbles; the lungs were congested, all the other organs were normal.

The most interesting and convincing case is related by Ols-hausen. It is the most convincing on account of the painstaking and accurate post-mortem examination which was made to determine the cause of death. (*Monatsschrift f. Geburtskunde*, January, 1865; *Amer. Journal Medical Sciences*, July, 1865.) A robust secundipara, aged 29, was delivered at full term. The uterus was unusually distended; no albumen in urine. The labor was lingering, and the uterine douche was used. The water of 30° R. was forced into the vagina gently by a pump. A third injection was made by a midwife. After eight minutes' use the patient began to complain of oppression. The tube was withdrawn. The patient rose in bed, immediately fell back senseless, and died in less than a minute under convulsive respiratory movements and distortion of the face. Eight minutes later, bleeding by the median vein was tried, but only a few drops flowed. On touching the body, distinct and widespread crepitation was felt. Autopsy eight hours after death. A large quantity of dark fluid blood escaped from the sinuses of the dura mater. The cerebral membranes very hyperæmic, brain normal, lungs somewhat congested, heart lying transversely, apex in fourth intercostal space. Left ventricle in firm contraction, right quite soft, something like an intestine with thick walls; the coronary vessels contained a quantity of

air-bubbles. Left heart contained only a small quantity of blood; the right held little, but it was frothy. The distended uterus crepitated everywhere on pressure under the hand. A number of subperitoneal vessels of medium size were plainly filled with air. The right broad ligament was strongly distended with air-bubbles, and this emphysema of the cellular tissue extended from the broad ligament through the retro-peritoneal space to the inner side of the right kidney, and even below the liver to the inferior vena cava. *The inferior vena cava was enormously distended*—it was at least an inch in diameter—containing mostly air. The uterus was divided in the median line; a placenta was attached to the anterior wall; a small flap was detached from the uterus. A second placenta was attached behind and to the right; a larger portion of this had been separated, so that there was a sort of a pouch between it and the anterior wall. The two ova were uninjured. The air had gained access into the veins at the placental site. It was concluded that the tube had been passed into the uterine cavity, and that air had been thrown in with the water by the pump.

It would be difficult to conceive in what manner air could be drawn into the uterine veins by the aspiratory movements of the chest or heart, as is the case in the veins about the apex of the chest. Another explanation must be sought for, and this will be found in the change of structure, and the relations of the uterine veins. The veins during pregnancy keep pace with the enormous physiological hyperplasia of the uterine tissues, and are gradually converted into large sinuses, more especially the vessels at the placental site; they are simply excavations or channels in the contractile muscular walls of the uterus, their size being subject to the state of the uterine walls, whether at rest, relaxation or contraction. When the placenta is detached, some of the sinuses are laid open, and in a normal condition their calibre is obliterated by the contractions of the uterus and the formation of thrombi. If from any cause air should reach the uterine cavity, it may be aspirated into the uterine sinuses by relaxation of the uterine contractions, and, having gained access into them, it is readily forced into the circulation by subsequent contractions, the uterine walls acting

the part of a suction and forcing pump. During forcible uterine contractions the veins are nearly emptied of their contents, and, as the organ relaxes, the walls of the veins are distended and a vacuum is formed, which is filled with blood or air. Should the relaxation be slow, the empty spaces are readily filled with blood or serum in the absence of air, but if the uterus relaxes quickly, the suction power is proportionately greater; and, in the event air has reached the uterine cavity, it is aspirated into the open veins, and by reaching the right side of the heart through the vena cava it gives rise to the same train of symptoms as when it is admitted into a vein during a surgical operation in the regions of the neck.

Pulmonary Vein. Dumin's case (*Berliner Klin. Wochenschrift*, January 30, 1882.) This is the only case on record where it is claimed that death was produced by the entrance of air from a pulmonary tubercular cavity through the pulmonary vein into the left side of the heart. The patient was a young man suffering from pulmonary tuberculosis in the last stage. Physical diagnosis revealed a large cavity in the apex of the right lung. After the patient had been in the hospital for three weeks the general condition remained about the same, while the local destructive process had been progressing. One day after eating his dinner, he arose from his bed, fell down, and expired almost instantly without uttering a word or sound. At the post-mortem examination, 24 hours after death, it was found that the apex of the lung contained a cavity of considerable size, beside extensive crude infiltrations. The left lung contained numerous nodules and three small cavities. The third cavity in the substance and near the base of the lung contained a small amount of blood intimately mixed with air-bubbles. The heart was slightly dilated. The left ventricle was filled with blood mixed with innumerable small air-bubbles. The right cavity also contained air, but in much lesser quantity. All the larger arteries contained air mixed with blood; air-bubbles were also found in the venæ cavæ and the pulmonary artery. The arteries and veins in the brain and meninges were found distended almost exclusively with air. No signs of advanced putrefaction could be found, and none of the parenchymatous organs contained gases. The reporter explained

the sudden death by the entrance of air from the small cavity in the left lung, which contained spumous blood, the air having found its way into an open branch of the pulmonary vein, and thence into the left side of the heart. The air which was found in the right side of the heart and veins, according to his view, had passed through the systemic capillaries. As the direct cause of death, anæmia of the brain is mentioned.

Remarks. It seems to me that several reasons might be mentioned which would throw doubt on the correctness of the assertion that in this case the immediate cause of death was owing to entrance of air into the pulmonary vein. 1. The time which had elapsed from the commencement of the attack until death took place, was not sufficient to produce such an extensive distribution of air, unless it could be proved that the heart's action continued after respiration had ceased. 2. The existence of an open vessel in any of the cavities was not proven at the examination after death. 3. The body appears to have been affected by a certain amount of putrefaction, which may have been sufficient in degree to give rise to the evolution of gases, and the putrefactive changes may have been limited to, or were, at least, farthest advanced in the blood, which would explain the absence of gas in any other part of the body except within the blood-vessels. 4. Syncope is a frequent cause of sudden death in greatly debilitated patients when the heart is called upon suddenly to perform an increased amount of labor, as when the patient suddenly assumes the erect position.

Superior Longitudinal Sinus. Volkmann's case. (*Verhandlungen d. Deutschen Gesellschaft f. Chirurgie*, Vol. VI., p. 32.) The only fatal case of admission of air into the sinuses of the dura mater is reported by Genzmer. The patient was a female, 63 years of age, who was affected with a perforating sarcoma of the dura mater. The tumor was noticed about two years before the operation, and was located in the region of the posterior extremity of the sagittal suture, and for a long time gave rise to no inconvenience. For the last six months it caused intense headache. On one occasion, a physician, believing it was an atheroma, attempted its removal, but, as the first incision gave rise to copious hemorrhage, he desisted from any fur-

ther attempts, and the wound healed kindly. When the patient was admitted under Volkmann's care into the Clinic at Halle, the tumor presented a lobulated appearance, being composed of three parts, each about the size of a plum, and was located over the posterior extremity of the sagittal suture. On touch, the tumor was soft and elastic, and imparted to the finger distinct pulsations. Gradual compression reduced its size one-half; when the pressure was discontinued it resumed its former dimensions. On auscultation a blowing sound was heard synchronous with the radial pulse. By pressing the end of the index finger deeply between the lobes of the tumor a bony defect in the skull was readily detected. The conclusion was reached that the tumor had sprung from the dura mater, and had perforated the skull by the prolonged pressure, causing interstitial absorption of the cranial vault. During the patient's stay in the hospital the tumor increased very rapidly in size. As no brain symptoms were present, it was assumed that the substance of the brain was intact. In view of the speedily fatal issue which, of necessity, would take place without operative interference, Volkmann decided to remove the tumor. The operation was done April 2, 1875. Under strict antiseptic precautions the tumor was exposed by a crucial incision, and the flaps reflected with the periosteum to the margins of the opening in the skull. The aperture in the bone measured $5\frac{1}{2}$ by $4\frac{1}{2}$ cm. in diameter. With a Lucr's cutting forceps the opening was enlarged to 7 by 8 cm. The tumor, when exposed, was nearly as large as a fist, and firmly adherent to the dura mater. The dura mater was carefully divided around the margins of the tumor, which had now been liberated from all its attachments except the falx cerebri. It was now drawn forward through the opening in the skull and the falx cerebri divided with scissors from before backwards. This step of the operation was attended by alarming hemorrhage. As the blood was being sponged away to expose momentarily the field of operation, a peculiar and characteristic lapping sound was heard, which indicated to all present, that air had entered the longitudinal sinus. At the same time, the assistant, who was giving chloroform, remarked: "She is dying." The wound was immediately compressed with a large carbolized

sponge. The patient was in collapse, her breathing was interrupted and stertorous. After a short pause it was determined to complete the operation, but as soon as the tumor was again drawn forward, and its attachment at the junction of the longitudinal with the transverse sinuses was divided, air again entered, accompanied by the same characteristic sound. The tumor was separated rapidly from its remaining attachments, and a Lister dressing was applied in such a manner as to make, at the same time, a requisite amount of compression for the double purpose of arresting hemorrhage and preventing further ingress of air. At this time the patient was pulseless, pupils dilated, extremities cold and blue. Autotransfusion by constricting the arms and legs with elastic bandages had the effect of momentarily stimulating the heart, but respiration became more irregular and interrupted, and after a few more brief moments the patient died. At the post-mortem examination, which was held on the following day, the right side of the heart was opened under water, air-bubbles escaped, showing conclusively that air had made its entrance through the longitudinal sinus. The left side of the heart contained no air. Air was also found in the pulmonary artery and the subpleural vessels. The left side of the brain had suffered more from compression by the tumor than the right. The defect in the dura mater corresponded to the opening in the skull. An additional source of hemorrhage was detected at the posterior margin of the defect in the cranium where the opening of a vein in the substance of the bone 5 mm. in diameter could be seen. Under the microscope the tumor showed small spindle-shaped cells, with a very vascular intercellular substance.

Remarks. In this case, all circumstances favored the entrance of air into the wounded sinus. The sudden and severe loss of blood from such a large reservoir as the longitudinal sinus rendered the vessel empty, thus creating the most essential element in the causation of air aspiration. The position of the patient during the operation, undoubtedly was such that the force of gravitation assisted materially in the formation of a vacuum. The walls of the sinus being rigid and attached to the surrounding structures prevented collapse of the vessel and held the wound patulous. That death was owing to the

introduction of air is sufficiently proven by the symptoms during life and the evidences derived from the post-mortem examination.

Veins of Diplôme. Franck (*Sur la transmission de l'aspiration thoracique jusqu'aux canaux veineux des os du crâne, etc. Gazette Méd.*, 1881, No. 25) asserts that he has repeatedly seen aspiration of air into the veins of the diplôme after trephining. He claims that the air reaches the heart through the medium of the vertebral veins which, from their protected position, are more favorably located for this purpose. By experiments he proved that ligation of the jugular veins does not prevent the aspiration of air through the veins of the diplôme, while, on the other hand, this accident cannot happen when the vertebral veins are compressed. As the veins of the diplôme, in some instances, are unusually large, and their walls firmly attached to the unyielding bone tissue, they constitute channels which cannot contract in the event they are injured, consequently we should, *a priori*, expect that aspiration of air will take place under the same circumstances as in the case of the sinuses of the dura mater, and, in all extensive injuries of the cranial bones the same caution should be exercised to guard against this accident. In troublesome hemorrhage from venous sinuses in bone the bleeding is promptly and safely arrested by implantation of an aseptic sponge which can be left *in situ* as it will be removed by the granulation tissue during cicatrization. In such instances the sponge is peculiarly well adapted, as the lumen of the vessel is surrounded by unyielding bony walls which will support any amount of pressure on part of the aseptic tampon.

[To be continued.]